SA-381 CIVIL AERONAUTICS BOARD File No. 1-0001

AIRCRAFT ACCIDENT REPORT

ADOPTED: November 14, 1966 **RELEASED:** November 17, 1966

EASTERN AIR LINES, INC., DC-7B, N849D
IN THE ATLANTIC OCEAN 6.5 NAUTICAL MILES
SOUTH-SOUTHWEST OF JONES BEACH
LONG ISLAND, NEW YORK
FEBRUARY 8, 1965

SYNOPSIS

Eastern Air Lines, Inc., Flight 663, a DC-7B, N849D, en route from John F. Kennedy Airport to Richmond, Virginia, crashed in the Atlantic Ocean 6.5 nautical miles south-southwest of Jones Beach, Long Island, New York at 1826 e.s.t., February 8, 1965. The 79 passengers and 5 crewmembers perished in the crash and the aircraft was destroyed.

Flight 663 was climbing in a southerly direction after departing JFK Airport at 1820. At the same time Pan American Flight 212, a B-707, inbound to JFK from Puerto Rico was descending to land. At 1827 the Pan American crew reported a near miss with another aircraft and that, "It looks like he's in the bay then, because we saw him. He looked like he winged over to miss us and we tried to avoid him, and we saw a bright flash about one minute later."

The Board determines that the probable cause of this accident was the evasive action taken by EAL 663 to avoid an apparent collision with PAA 212. The evasive maneuver of EAL 663, prompted by illusion, placed the aircraft in an unusual attitude from which recovery was not effected.

1. INVESTIGATION

1.1 History of the Flight

Eastern Air Lines, Flight 663, (EAL 663) was a regularly scheduled passenger flight originating at Boston, Massachusetts, and terminating at Atlanta, Georgia, with intermediate stops at New York, Richmond, Virginia, Charlotte, North Carolina and Greenville-Spartanburg, South Carolina. The flight operated between Boston and New York without reported discrepancies.

EAS 663 took off from runway 31L at John F. Kennedy Airport at 1820[1/] on an Instrument Flight Rules (IFR) clearance to the Richmond Airport. The aircraft was cleared to maintain 8,000 feet after making a Dutch 7 Standard Instrument

1/ All times herein are eastern standard based on the 24-hour clock.

Departure[2]/ (SID). Shortly after takeoff the flight reported out of 1,000 feet and was instructed to turn left to a heading of 160 degrees. At approximately 1823, upon request, the flight reported its altitude as 2,500 feet and was instructed by Departure Control to turn left to a heading of 100 degrees. Shortly thereafter EAL 663 was further cleared to 8,000 feet and instructed to turn right to a heading of 150 degrees. The flight acknowledged this clearance and reported leaving 3,000 feet.

At approximately 1824, in response to another query from Departure Control, EAL 663 reported leaving 3,500 feet at which time the flight was instructed to turn left to a heading of 090 degrees.

After approximately 1825, in response to still another inquiry concerning its altitude, EAL 663 reported, "Out of 3,700 (feet)." Twenty-seven seconds later Departure Control instructed the flight to ". . . turn right now, heading one seven zero to Victor one thirty nine, traffic 2 o'clock five miles northeast bound below you." The flight responded, "OK we have the traffic, turning one seven zero. . .

At 1825:36[3]/ Departure Control instructed EAL 663 to contact the New York Air Route Traffic Control Center (ARTCC) on 125.1 mcs. The flight replied, "Good night." This was the last communication from EAL 663.

During the time that EAL 663 was departing, Pan American World Airways Flight 212 (PAA 212), a Boeing 707 on an Instrument Flight Rules (IFR) flight plan from San Juan, Puerto Rico to New York, was approaching to land at JFK Airport. At approximately 1818, the ARTCC initiated a radar handoff to Kennedy Approach Control and reported that PAA 212 was then three miles north of the Dutch Intersection.[4]

PAA 212 was subsequently provided with radar vectors to intercept the final approach course to runway 31R and cleared to descend from 10,000 feet to 3,000 feet. At approximately 1824 Approach Control instructed the flight to turn right to a heading of 020 degrees and inquired if the flight had as yet reached 3,000 feet. Approach Control then instructed the flight to report leaving each 500-foot level down to 3,000 feet and advised the flight of ". . . Traffic at 11 o'clock, six miles southeast bound just climbing out of three (3,000 feet)."

At the public hearing the captain of PAA 212 testified that he observed the traffic, as reported, moving west to east; that it was identified by its flashing beacon; that the other aircraft (beacon) appeared to be in a normal climb slightly above their flight level coming up into the strip of sky visible above the shore lights. He started a turn to 360 degrees as instructed by Approach Control. At about this time, ". . . the beacon altered direction and to what appeared to be a more southeasterly heading and instead of proceeding from west to east it seemed to alter direction to the right and proceeded in a more

2/ Dutch 7 Departure - After takeoff from runway 31L/R, climb on a 290-degree heading to 1,000 feet m.s.l., turn left heading 160 degrees for two minutes. Cross Kennedy VORTAC 224-degree radial at 2,500 feet m.s.l., then via vector to V139; V139 to Dutch Intersection. Cross Riverhead VORTAC 237-degree radial at or below 4,000 feet.

3/ Times used hereafter when detailed to the second are based on the beginning of the communication associated therewith unless otherwise noted.

4/ Intersection of the 170-degree JFK VORTAC radial and the 236-degree Hampton New York VORTAC radial, approximately 41 miles south-southwest of Kennedy Airport

southerly direction or an approximate south direction." According to the captain the other aircraft was then about four miles away. He stated, "This caused us to monitor the progress of the beacon, the other flight, a little more continually and as it was approaching, our headings were more or less 180 degrees apart . . . the aircraft got closer, it looked like we may be on a course where this (the other aircraft) would overhead our aircraft, and to keep the aircraft in sight, I moved off, started a turn to the right and started the aircraft down. Somewhere in this right turn . . . (the first officer) whose monitor had been almost continuous on this aircraft, recognized what seemed to us to be a very rapid deterioration of altitude and the aircraft (EAL 663) seemed to no longer be moving where it would come by on our left but was going to cross, and somewhere very shortly after the initial indication of this right turn, . . . made the statement . . . 'No Bob down' . . . at about the same time it seemed to me that something had to be done very quickly to avoid what was becoming an imminent situation, so I pushed the aircraft down forcibly and rolled it hard to the left to roll underneath the target. It was a very short duration because the target was over and gone. At no time while I had the aircraft in sight did it cross the 12 o'clock position."

The captain stated further, "The clearest recollection I have at this point is seeing a bright row of cabin window lights, - a great number of them. My impression was that the aircraft was in a vertical bank or close to a vertical bank and that I was looking at the right hand cabin light on the side of the fuselage. I felt as though I saw a silhouette of the aircraft standing on its right wing. The aircraft passed over my aircraft at an altitude of something below 500 and maybe above 200 (feet). . . shortly after the crossover of the other aircraft we saw a very large red glow emanate from behind . . . while we were still in the left wing-down condition turning to the new heading (360^{o}) we were able to see the fire on the water." He estimated that the time between the initial and last sighting of the traffic (EAL 663) was about a minute and a half.

The first officer of PAA 212 testified, "As we were descending from an altitude of 4,000 feet to our last clearance limit altitude of 3,000 feet, I became concerned with traffic of which we had been notified and seen . . . This aircraft appeared to me to be making a climb, and, of course, it was moving from our left to the right, across our path of flight." He said that the other aircraft, identified by its beacon, started toward PAA 212 very close to their altitude; that the turn was then rapid and that he said to the captain, "This guy is getting too close, let's go down." The captain looked out at the traffic and started to roll the aircraft into a right bank. After the right bank was initiated, he related, ". . . I am getting a very definite impression that this altitude separation is really starting to deteriorate very rapidly. Now this thing is coming right down, and in my mind, I am also beginning to think that even though this is coming at us, I have the impression that it is going to possibly pass to the right of us. So immediately I want to stop this turn but I want to get down; I want to get away from this thing that is coming down on us. So apparently at this time when I said 'No down,' I reached for the control wheel. Well apparently (the captain) must have arrived at this same conclusion about the same time, because as I got my hand on the wheel - I think this is where the 'Yeoh' (an exclamation on the communication tape at 1826:19) came in . . . when I grabbed for the aileron, I caught the trigger switch on my boom mike, . . . but as I got my hand on the wheel I felt him rolling . . . out of the bank and starting to go forward on it. This is the time I noticed the forward push on the yoke because now I had my hand on it."

The first officer also stated that PAA 212 was in a level position when the other aircraft went by; that the other aircraft at that time was in a 90-degree bank slightly nosedown; that he saw the mid sections of both wings inboard of the aileron, and the hump of the fuselage; that the separation between the two aircraft was 200 to 300 feet; that he had the definite impression that he heard engine noise; that the other aircraft was four to five miles from PAA 212 when it made the right turn; and that the time after the turn to passing his aircraft was 40 to 50 seconds.

The flight engineer aboard PAA 212 testified that when advised of the traffic at 11 o'clock he saw a red beacon which looked like the aircraft was climbing; that he definitely thought the other aircraft was below PAA 212 and that after his first observation he did not again see the traffic. He said the sequence of maneuvers of PAA 212 was a right bank, a roll back out of the bank to a wings level attitude, and the other aircraft went by them. He thought he heard aircraft engine noise as the other aircraft passed but he did not see the other aircraft.

PAA 212 reported a near miss at approximately 1827, at which time the radar target associated with EAL 663 was no longer visible on the approach control radar scope. At about this time reports were received by various controllers in both Kennedy Tower and the New York Center from other air crews who had observed an explosion and fire on the water.

Based on reports of other air crews in the area, EAL 663 crashed in the Atlantic Ocean approximately 13 nautical miles southeast of the JFK Airport (6.5 miles off Jones Beach, Long Island) at approximately 1826.

PAA 212 landed at JFK Airport at approximately 1831 without further incident.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	5	79	0
Non-fatal	0	0	0
None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed on impact.

1.4 Other Damage

There was no injury to other persons or damage to other property.

1.5 Crew Information

Captain Frederick R. Carson, age 41, held airline transport pilot certificate No. 444006 and type ratings in L-188, DC-6/7, L-749, DC-3, M202/404, and L-1049C/D aircraft. He was employed by Eastern Air Lines on February 14, 1946, and was upgraded to captain on July 22, 1952. His last proficiency check, in DC-7B type aircraft was satisfactorily accomplished on February 3, 1965. His last first-class medical certificate was issued on February 8, 1965, with no waivers.

Captain Carson had accumulated a total of 12,607 hours pilot time including 595 hours in DC-7B aircraft; had passed a line check on April 13, 1964, and an en route inspection on June 14, 1964.

First Officer Edward R. Dunn, age 41, held commercial pilot certificate No. 1337352 with airplane single-multi-engine land instrument, L-188, 1049, and DC-6/7 ratings. He was employed by Eastern Air Lines on June 18, 1956. His last first-class medical certificate was issued on January 14, 1965, with no waivers. Mr. Dunn had accomplished a total of 8,550 hours pilot time including 2,750 hours in DC-7B aircraft.

Flight Engineer Douglas G. Mitchell, age 24, held flight engineer certificate No. 1594733 and commercial pilot certificate No. 1399507 with airplane single and multi-engine land and instrument ratings. He was employed by Eastern Air Lines on September 23, 1963, and had a total of 407 pilot hours and 141 hours flight engineer time. His last proficiency check in DC-7B equipment was satisfactorily accomplished on January 4, 1965. His latest first-class medical certificate was issued on July 7, 1964, with no waivers.

Flight Attendants Linda A. Lord and Judith A. Durkin were both trained to serve as crewmembers on DC-7B aircraft.

The crew of EAL 663 had flown 1 hour and 16 minutes, and had been on duty 3 hours and 11 minutes during the day of the accident.

1.6 Aircraft Information

Eastern Air Lines records reveal that DC-7B, N849D, manufactured by the Douglas Aircraft Corporation on May 1, 1958, was delivered to Eastern Air Lines, Inc., Miami, Florida, on May 15, 1958, with 9:05 hours on the aircraft.

Maintenance records indicated that N849D was inspected and maintained in accordance with the standards set forth by the Federal Aviation Agency. There were no recurring discrepancies noted in the aircraft records. The gross weight of the aircraft at takeoff was 104,799 pounds. The maximum allowable takeoff gross weight was 126,000 pounds. The center of gravity was within allowable limits.

The engines were being operated on 115-145 octane gasoline.

1.7 Meteorological Information

The U. S. Weather Bureau at JFK reported the weather at 1838 to be: scattere clouds at 12,000 feet; high thin broken clouds; visibility 7 miles; and the wind from 250 degrees at 7 knots. The temperature was 46°F, the dewpoint 43°F, and the altimeter was 30.06.

The accident occurred during the hours of darkness. Air crews and ground witnesses in the vicinity at the time of the accident stated that no moon or stars were visible. Additionally, crewmembers of aircraft which were headed in the same direction as EAL 663 (south) stated that it was completely dark in that direction with no apparent horizon.

1.8 Aids to Navigation

There were no reported discrepancies of any involved ground navigation aids.

1.9 Communications

The departure radar controller established radio contact with EAL 663 at 1820:31. He instructed the flight to climb to 6,000 feet and report leaving 3,000. At 1821:11 EAL 663 reported5/ out of 1,000 feet and was instructed to turn left to a heading of 160 degrees.

At 1822:51 when interrogated concerning the aircraft's altitude, the flight reported 2,500 feet whereupon the DR-1 controller issued an instruction to turn left to a heading of 100 degrees and to change transponder to Code 11A. At 1823:34 EAL 663 was instructed to climb to 8,000 feet and to turn right to a heading of 150 degrees. At 1823:41 the flight acknowledged the last clearance and reported leaving 3,000 feet. At 1824:27 in response to another query from the DR-1 controller, EAL 663 reported leaving 3,500 feet at which time the flight was instructed to turn left to a heading of 090 degrees. At 1825:04 in response to still another inquiry concerning its altitude EAL 663 reported "Out of 3,700." Seventeen seconds later at 1825:21 the DR-1 controller instructed the flight as follows: ". . . turn right now, heading one seven zero to Victor one thirty nine, traffic 2 o'clock five miles northeast-bound below you." The flight responded that they had the traffic and were turning to the assigned heading.

At 1825:36 in response to an instruction from the DR-1 controller to contact the New York Center on 125.1 mcs. the flight's last transmission was "Good night."

Pan American Flight 212 (PAA 212) was on a Instrument Flight Rules (IFR) flight plan from San Juan, Puerto Rico, to JFK Airport. At 1818:38 the New York Air Route Traffic Control Center initiated a handoff to the Kennedy Approach Control Arrival Radar Handoff (ARHO) controller and advised that PAA 212 was then three miles north of the Dutch Intersection. ARHO accepted radar identity of the target and instructed the New York Center to have the traffic turn (from 330 degrees) to a 350-degree heading.

At 1819:31 the handoff was completed when PAA 212 established radio contact with Kennedy Approach Control (AR-3), reported leaving 10,000 for 4,000 feet, and advised that the flight had received Information Golf.6/ At 1819:46 PAA 212 was instructed to maintain its present heading for a vector to the final approach course (for runway 31R) and cleared to descend to 3,000 feet.

At 1820:08 the AR-3 controller requested PAA 212 to report leaving 6,000 feet. This report was made at 1822:45

At 1823:39 the AR-3 controller requested PAA 212 to report reaching 3,000 feet. At 1824:19 the controller instructed the flight to turn right heading 020 degrees and the message concluded as follows: ". . . say again your altitude,

5/ The voice making all transmissions from EAL 663 was identified as that of the first officer.

6/ Information for arriving aircraft transcribed and broadcast on the voice feature of the Colt's Neck, New Jersey and Deer Park, New York VORTACs.

you say you're at three?" The flight reported leaving 4,500 feet and acknowledged the heading change.

At 1824:48 the AR-3 controller requested PAA 212 to report leaving each 500-foot level down to 3,000 feet and advised the flight of traffic at 11 o'clock, six miles southeastbound just climbing out of 3,000 feet. PAA 212 reported leaving 4,000 feet and four seconds later at 1824:56, advised, "We have the traffic."

At 1825:37, in response to another inquiry from AR-3 concerning the aircraft's altitude, PAA 212 reported out of 3,500 feet whereupon at 1825:47 the flight was instructed to turn left heading 360 degrees and to contact approach control on 118.4 mcs. The frequency change was accomplished and at 1826:06 PAA 212 established communications with the final vector controller (AR-1).

The flight was advised of its observed position (13 miles southeast of the airport) and asked its altitude. PAA 212 replied at 1826:12 "Level at 3,000" (feet) whereupon the AR-1 controller cleared the flight to descend to 2,000 feet and maintain a 360-degree heading. This clearance was not acknowledged.

At 1826:19 an exclamation appeared on the communications recording tape the sound of which is described as "Yeoh." The transmitter from which this exclamation emanated remained on the air and the carrier background hum was identical in pitch and volume to that associated with all previous and subsequent transmissions from PAA 212.

At 1826:23 and again at 1826:39 the AR-1 controller attempted to obtain an acknowledgment for the descent clearance and heading assignment. At 1826:42 a crewmember aboard PAA 212 reported a "close miss" with another aircraft. He asked the AR-1 controller, "Did you have another target in this area at this same spot where we were a minute ago southbound?" When the AR-1 controller advised him that he did and that the traffic was no longer visible on his radar scope, PAA 212 replied at 1827:10 "It looks like he's in the bay then, because we saw him, he looked like he winged over to miss us and we tried to avoid him, and we saw a bright flash about one minute later."

At 1827:25 another voice (later identified as that of the captain of PAA 212) stated ". . . he was well over the top of us and it looked like he went into an absolute vertical turn and kept rolling."

Kennedy Approach Control provided radar vectoring service for inbound PAA 212 while Kennedy Departure Control7/ provided radar vectors for outbound EAL 663.

7/ (1) Controls IFR departure traffic . . . in accordance with the provisions of the Kennedy Tower and New York Center Letter of Agreement and Supplements thereto; (2) Provides standard radar/nonradar separation to all IFR departures from Kennedy Airport; (3) Responsible for all radar handoffs to the appropriate center sector unless these handoffs are accomplished by a GS-12 radar controller; (4) Insures that all necessary altitude restrictions are met;* In addition pertinent supplements to the Letter of Agreement are directed to Kennedy Tower facility operation position definition;

(continued on next page)

The DR-1 controller testified that when he coordinated with the AR-3 controller (handling PAA 212) the DR-1 controller advised the AR-3 controller that the DR-1 "Might possibly have an aircraft that would be unable to cross the 157-degree (radial of JFK) at four thousand feet. He advised me that he had one still far away in the general direction of Dutch . . . but at this time (it was) no factor." The initial coordination between the AR-3 and DR-1 controllers took place at approximately 1823, or shortly after the DR-1 controller turned EAL 663 to a 100-degree heading. Both controllers testified that at approximately 1823:24 further coordination and an exchange of altitude information was effected. However, a review of the transcription of recorded communication at the DR-1 position revealed that this controller was engaged in almost continuous communication with EAL 663 and other aircraft during this time period.

In the public hearing the AR-3 controller, when asked why he had requested PAA 212 to report each 500-foot level, stated: "It was a form of preplanning . . . I noted that information in the event that I couldn't maintain radar separation between the two aircraft I would have immediate knowledge of the Pan American's altitude and with further coordination (with the DR-1 controller) . . . I could revert to standard nonradar separation."8/

In support of his reliance on radar separation between the two aircraft the AR-3 controller stated: ". . . Eastern 663 was observed completing a right turn from an easterly heading approximately four miles ahead of and to the right of Pan American 212 (then on a heading of 20 degrees.)" According to his testimony, shortly thereafter he issued a new heading of 360 degrees for the Pan American aircraft, and to give him a better angle of intercept with the glidepath. ". . . to turn him toward the airport." He then instructed the flight to contact the AR-1 controller.

The Approach Control Sequencer of the Kennedy Tower received a radar handoff from the AR-3 controller on PAA 212, and passed it to the AR-1 controller. He stated ". . . I assumed the departure (EAL 663) had reached 4,000 feet. He was in an area where he should have been maintaining a level of 4,000 or flying it at any rate, but in my mind the radar separation did still exist and would continue to exist."

7/ (Continued from p. 7)
Standard operating radar procedures are also established for: (1) Departure Control; (2) Departure traffic shall be vectored in accordance with the instruction contained in the facilities operating definition; (3) ..... (4) ..... (5) Departures off runway 31L/R shall be vectored so as to remain within the five mile range mark (of the JFK ASR-4 radar) until crossing the Kenne VORTAC 157-degree radial unless prior coordination is effected.

* When takeoffs on 31L/R and approaches to the northwest were in use at JFK there are two specific flight restrictions applicable to aircraft destined for points south of New York via the Dutch 7 SID. They were: Cross the 157-degree radial of JFK VORTAC at 4,000 feet or higher and; remain on/or north of the JFK 141-degree radial until 3.5 miles east of the Deer Park 228-degree radial.

8/ The minimum distance between aircraft required for radar, lateral or horizontal separation is three miles. The required distance between aircraft for vertical or nonradar separation is 1,000 feet.

According to the testimony of the AR-1 controller PAA 212 advised they were "Level at 3,000." Thirty-six seconds from the time of this initial contact with the AR-1 controller PAA 212 reported the "close miss."

The AR-1 controller stated that he issued radar vectors to his inbound traffic to provide separation between his aircraft and other inbound targets under his control in the area and that this was horizontal (radar) separation which required three miles. He further stated: "When Pan American advised me that he had had the close miss and he is really talking in reference to behind him well I really can't say whether or not in reference to behind him but now I am looking directly at him, and I see another target come away from his beacon code. This is when I first observed the target south or southwestbound."

Concerning EAL 663 the DR-1 controller testified that he was "strictly interested in lateral separation" between the two aircraft. He stated ". . . I remember very vividly that Pan American was well to the right of Eastern - it would be his 3 o'clock position - when he (EAL 663) started his turn. It was five or six miles. There was more than ample separation."

The Departure Radar Handoff (DRHO) controller who effected the handoff from the DR-1 controller to the radio-radar controller (RR-7) in the New York Center was asked if he believed radar separation was being applied. His answer was "definitely." He further stated that when the DR-1 controller turned EAL 663 to 090 degrees there was adequate radar separation at that time. Later when he observed or overheard the DR-1 controller turn EAL 663 to a 170-degree heading the distance between the two targets was four to five miles.

At approximately 1825 the DRHO controller attempted a radar handoff of EAL 663 to the RR-7 controller. The RR-7 controller stated: ". . . The aircraft was approximately three miles from the Deer Park VORTAC 228 radial on the Kennedy 160-degree radial. I observed the target but also another target at his 1 o'clock position approximately eight miles away on converging course. I knew the second target to be Pan American Flight 212 whom I turned over to Kennedy Approach Control radar approximately six minutes earlier on a heading of 350 degrees. . .I inquired if separation existed between the two flights. The DRHO controller indicated to me that Eastern 663 was above his traffic. A few seconds later the Kennedy Departure Controller called me back and advised that they were going to retain control of Eastern 663 because they didn't have quite a thousand feet. About a minute later I observed Eastern Air Lines 663 make a left turn toward the northeast tracking approximately 070 degrees. Approximately three miles or more, possibly five, after I observed the first turn toward the northeast I observed a turn to the right by the aircraft. Eastern 663 made a right turn to a southerly heading at almost the same spot where he commenced his turn. I estimate it took approximately two sweeps of the radar from the time Eastern 663 commenced his turn to the right until I saw him on a southerly heading. At this point Eastern 663 and Pan American 212's targets merged but I could still distinguish them as two targets."

As to the kind of separation being provided the RR-7 controller said that with the departure handoff controller's statement of "not quite a thousand feet" departure control was going for vertical separation. However, at a later point in his testimony he said "It was radar separation prior to Eastern starting to turn. Once (the aircraft) . . . proceeded southbound, once he was on a southerly heading--the radar separation was lost on my scope."

1.10 Aerodrome and Ground Facilities

Neither the field investigation nor the public hearing revealed any facts which would indicate that aerodrome or ground facilities were in any way contributory to this accident.

1.11 Flight Recorder

EAL 663 was not equipped nor required to be equipped with a flight recorder.

PAA 212 was equipped with an operating Lockheed Model 109C serial No. 188 flight data recorder. From an examination of the flight record the heading parameter trace appeared to be inscribed incorrectly relative to its position on the foil. It was discovered that a replacement servo amplifier unit input signal lead had been inadvertently switched at the terminal posts, resulting in a 180-degree phase reversal of the output to the stylus drive. (See Attachment #1.)

The readout indicated no significant variation in any of the four parameters until five minutes and ten seconds prior to touchdown. At this point for ten seconds duration, a pushover maneuver is indicated by negative acceleration increment up to 1/2-g magnitude followed by a positive acceleration force of lesser magnitude before returning to normal. During this period variations also transpired in the other three parameters which coincide with the avoidance maneuver described by the crew i.e., heading change to the right, increase in airspeed and decrease in altitude.

1.12 Wreckage

The wreckage of EAL 663 was located by Sonar Soundings on the ocean floor at a water depth of 70-80 feet. The location of the crash site was 13 nautical miles southeast of the JFK Airport. (See Attachment #2.) Wreckage distribution was confined generally to an area 125 yards wide and 400 yards long.

Over 60 percent of the aircraft was recovered, including portions of all major components. The investigation revealed no evidence which would indicate failure or malfunction of the aircraft's powerplants, systems, or structural components prior to impact.

The fuselage components from the area below the reference plane were extensively fragmented. This included the heavily constructed center section containing the front, center, and rear spars. A portion of the fuselage nose section top skin was recovered torn aft and upwards and the nose section was crushed and torn. The right side crew entry door was crushed and torn from the forward leading edge aft and upward. All four engine power cases were recovered from an area 30 yards square, 350 yards from the main wreckage area, on a bearing of approximately 220 degrees.

All the control surfaces including trim tabs were recovered, damaged but with no indication of pre-impact malfunction or failure. All of the control cables recovered exhibited complete separation and all strands were necked down at the separation points.

All the landing gears were recovered, separated from their attachment points. The retract actuating cylinders were in the retract position. Both main landing gears had engine oil cooler core material imbedded between the inner brake assembly and between the oleo piston and the torque links.

The flaps and flap actuator mechanisms were recovered with the actuators in the retracted position.

There was no evidence of inflight fire or explosion.

1.13 Fire

Air crew eyewitnesses aboard Braniff Flight 5, Air Canada Flight 627, and Pan American Airways Flight 212 indicated that there was an explosion on the water and an ensuing major fire of short duration. As the captain of Braniff 5 stated: "The duration of the major fire was . . . only seconds."

1.14 Survival Aspects

All evidence indicated that this was a non-survivable type accident.

1.15 Tests and Research

During the course of the investigation photographs were taken from inside an EAL DC-7 and a PAA B-707 aircraft. These photographs depict the outside visibility through each cockpit window from both the captain's and first officer's eye position.9/ Since head movement by the flight crew has a considerable effect on this visibility, two photos from each position were made. One was from the normal eye position while the second was from the alert position (5 inches forward of the normal eye position). A study was made of these photographs to determine at what point the crew of EAL 663 could first detect PAA 212, and to determine the attitude of EAL 663 at various points of observation by the PAA 212 crewmembers.

Traffic was given to Flight 663 at 1825:21. It was reported that this traffic was at the 2 o'clock position at five miles and below. The crew of Flight 663 acknowledged the traffic at 1825:31. (PAA 212, at the time traffic was given to Flight 663, was, in fact, at about its 3 o'clock position. This was substantiated by the testimony of the departure controller during the hearing on this accident).

From the testimony of the air traffic controller, the flight crew of PAA 212 and the DC-7B performance data, the flightpaths of the two airplanes were reconstructed. From these data it was determined that EAL initiated its right turn from a 090-degree to a 170-degree heading at 1825:43. At this time it was computed that PAA 212 was at the 90-degree or 3 o'clock position from EAL 663 at a range of 24,000 feet and 700 feet below EAL 663. PAA 212 was on a heading of 020 degrees. The approximate true airspeeds for the two aircraft were estimated to be 180 knots for EAL 663, and 208 knots for PAA 212. Both flight crewmembers of PAA 212 indicated that EAL 663 made a very rapid right turn toward their position. Additionaly the RR-7 controller indicated that the aircraft appeared to make a rapid right turn within two sweeps of his antenna. From this information it was calculated that a 35-degree banked turn was made by Flight 663.

With the aforementioned data the paths of the two airplanes were reconstructed to determine the angle of elevation of the target airplane and the captain's visual altitude limitations from his alert position at the various ranges of the target aircraft. Table I indicates the bearing, range, and angle of elevation of PAA 212 from Flight 663 in five-second increments. The right 35-degree bank is

9/ EAL policy requires that captains of four engine equipment occupy the left seat during all flight operations.

started at time X and rollout on a 170-degree heading at time X + :18 seconds. An average altitude differential of 700 feet was utilized throughout the development of these elevation angles.

Table I

PAA 212 ELEVATION ANGLE

Time	Bearing	Range	Delta Altitude	Tangent Angle	Angle of Elevation
X	90°	24,000'	-700	.0292	-1°40'
X + :05	71°	22,250'	-700	.0314	-1°48'
X + :10	52°	19,800'	-700	.0350	-2°02'
X + :15	32°	17,000'	-700	.0412	-2°21'
X + :20	17°	13,900'	-700	.0503	-2°53'
X + :25	17°	10,600'	-700	.0660	-3°47'
X + :30	17°	7,500'	-700	.0935	-5°21'
X + :35	18°	4,250'	-700	.165	-9°22'
X + :40	22°	1,125'	-700	.622	-31°53'

Table II indicates the captain's visual altitude limitations in the same five second intervals at the various ranges and bearings of PAA 212. It is noted that from bearing 17° range 13,900' to bearing 17° range 7,500' the captain could have been in a position to see PAA 212. It is noted from Table I that when PAA 212 is at the 13,900' range the time is X + :20 which is after Flight 662 rolled out on the 170-degree heading.

Table II

Captain's Visual Altitude Limitations

		Upper Limit			Lower Limit		
Bearing	Range	Angle	Tangent Angle	Altitude	Angle	Tangent Angle	Altitude
90°	24,000'	+ 6°	.105	2560°	-12°	.213	-5,100'
71°	22,250'	-25°	.466	-1040'	-37°	.734	-16,400'
52°	19,800'	-17°	.306	-6050'	-33°	.649	-12,900'
32°	17,000'	- 9°	.158	-2690'	-24°	.445	-7,570'
17°	13,900'	17°	.306	4250'	- 6°	.105	-1,460'
17°	10,600'	17°	.306	3240'	- 6°	.105	-1110'
17°	7,500'	17°	.306	2300'	- 6°	.105	- 785'
18°	4,250'	16°	.287	1220'	- 6°	.105	- 446'
22°	1,125'	15°	.267	300'	- 5°	.087	- 98'

From the foregoing it was calculated that the captain was unable to see the traffic after starting his 35-degree bank until he had partially rolled out of his turn. The first officer, on the other hand, could probably have kept PAA 212 in sight throughout the entire time from initial detection until passage of the two airplanes.

Spatial Disorientation Study

The term "spatial disorientation" in its broad sense means the inability to determine one's position relative to one's environment. This inability results in

mental bewilderment and confusion. The aircraft pilot is susceptible to many types of illusions which result in spatial disorientation, such as vertigo, ocular gyral illusion, autokinetic illusion, and inadequate stimuli. Each of these types can be reproduced separately in a laboratory but they might be difficult to separate during actual flight. Some of these illusions will be considered separately herein.

Spatial disorientation results from reliance on the physiological sensing elements of the body which can give false or conflicting information to the senses. The primary device to provide orientation with respect to the horizontal, vertical, depth and distance is the eye. Vision, on the other hand, can give miscues to the physiological senses. A frequently experienced example of this miscue is an indication of motion when, in fact, you are standing still. In a stationary train the movement of an adjacent train often gives the impression that your train is in motion.

When vision is no longer available, instruments must be relied upon to eliminate disorientation. Rotation through many degrees for an extended period of time, twenty seconds or more, can give a false impression of straight flight due to the actions of the semicircular canals in the inner ear. Movement of the head during the rotation will result in the impression of a violent pitch up or down, dependent on the direction of rotation with relation to the direction of head movement. The literature on this subject is quite complete so that it will not be discussed at length herein.

Of particular interest in this accident are ocular gravic illusion results from the forces of gravity and acceleration acting upon the body where the body attempts to orient itself to the resulting vector of these forces.

J. R. Harper in the January-February 1965 issues of "Cockpit" reports that these sensations, if relied upon, would tell us only that we are going up or down or from side to side. He states that when a turn is entered with a 30-degree bank, our muscle and tendon pressures by themselves and without a visual horizon would tell us we are climbing. Reference to instruments would eliminate the effect of this illusion.

Autokinetic illusion results from the continual observance of an isolated light in the dark where no other visual references are available. The observed light, although in a fixed position, gives the impression that it is moving. The excursions of the light can be quite large and will be in different directions and magnitude for different observers. In order to experience this illusion the observer must fixate on the light for a period of about 20 seconds. Autokinesis can be easily broken by movement of the eye from the light to another object.

Commander Walter Goldenrath reported in the June 1965 Newsletter of SAFE (Space and Flight Equipment) as follows: "Inadequate stimuli or reduction in the intensity and quality of the visual stimulus will impart false sensations and ther by result in disorientation. These illusionary effects are caused by such factors as haze, glare, fog, dusk, and darkness. Even when they are not severe they will reduce the visual stimulus levels to a point where orientation to the earth or other objects becomes faulty. This is particularly hazardous when flying over sn water, or other areas barren of clearly defined landmarks. It results primarily im marked decrease in depth and distance perception."

In the Sperry Gyroscope Company Study10/one experiment was conducted to determine the effect of pilot warning indicators on the ability of the pilot to discriminate between aircraft on collision and noncollision courses. This experiment was conducted in the F-51 Gunnery Trainer at the FAA National Aviation Facilities Experimental Center. In this experiment, as the miss vector (distance between aircraft either vertically or horizontally) decreased, the frequency increased in which a decision was made that a collision course existed.

The evaluation of a target may depend on the observed angular velocity (sight line rate)11/ and the observed rate of change in angular subtense (range-rate)12/ rate of the target. If the sight-line rate of a target is well above the motion threshold the pilot can be fairly certain the target is on a non-collision course. However, if the sightline rate is below the motion threshold and there is a perceptible increase in apparent target size, the threat may be evaluated as a collis course.

Sight-line rates at final decision for courses judged as collisions by the pilots were about six minutes of arc per second regardless of the structure, or the miss vector, for vertical misses. For courses judged as misses (vertical miss vector) the line-of-sight rate was about nine minutes of arc per second. However, in these instances a horizon line was observable, and the pilots reported using this in addition to the "fixity of bearing"13/ criterion. For horizontal miss vectors of 1,000 feet (for which a reference line was not present) the sight-line rate was nearly 18 minutes of arc per second.

Near-Miss Investigation

On June 2, 1965, at approximately 2234 e.d.t., a B-707 and a DC-6 passed each other at 5,000 feet altitude in the vicinity of Freeport, New York. They were estimated to be separated by only 100 feet laterally at the time of passage.

The DC-6 was operating on an IFR clearance from Boston to JFK Airport. After holding at the Deer Park VORTAC at 6,000 feet the flight was cleared to depart on the 228-degree radial. The B-707 had been cleared to 5,000 feet on a heading of 100 degrees after departing JFK Airport. The DC-6 flight was given traffic at 2 o'clock, four miles eastbound, and below.

The DC-6 flight crew all indicated that they saw the traffic and estimated that the B-707 was at or above their altitude and on a collision course. The captain of the DC-6 took evasive action by diving his airplane from 6,000 feet to pass below the B-707 at 5,000 feet. The B-707 flight recorder readout affirmed the aircraft's altitude of 5,000 feet.

10/ A study of requirements for a Pilot Warning Instrument for Visual Airborne Collision Avoidance. Sperry Gryoscope Company - December 1963.

11/ Sight-line rate is the observed angular velocity or relative movement of a target in a horizontal or vertical plane.

12/ Range-rate is the observed rate of change in angular subtense of a targe or the rate at which the target appears to change in size as the range opens or closes.

13/ An apparent lack of relative motion of the observed target.

The lack of horizon and the black background conditions presented to the DC-6 flight crew were almost identical to those confronting the flight crew of Flight 663.

Flight Test Program

A flight test program was undertaken to reproduce as closely as possible the situation in which the crew of EAL 663 found themselves on the night of February 8, 1965. The Civil Aeronautics Board's Bureau of Safety staff assisted the FAA in the establishment of the program.

A total of four flightpaths were developed, three simulating possible tracks of EAL 663 and PAA 212, and the fourth simulating the conditions of the DC-6 and the B-707 near miss on June 2, 1965. In addition to the normal crew on the test DC-7 aircraft, three subject pilots were utilized on each of the three nights on which the flight tests were run. It was not the intent to reproduce the original flightpaths of the airplanes, but rather to find out the reactions of the subject pilots while in environmental conditions similar to those experienced by the crews in the aforementioned accident and incident.

Following are the intital reactions reported by the pilots involved in the tests. On the first night the subject pilots were briefed as to the expected altitudes of the two airplanes. This depth of briefing was discontinued on the two succeeding nights.

Of the six subject pilots who were unaware of the minimum vertical separation, five reported the illusion that the target (B-707) seemed to be climbing as it neared the DC-7 while, in fact, it was descending throughout the test. Two of the five experienced this illusion twice. Of particular significance was the report of one captain of the DC-7 that he had the illusion that his airplane was pitching over on the target aircraft. He checked his instruments to assure himself that he was still climbing but when he looked back at the B-707 he again experienced the illusion. This illusion occurred even though this captain had been fully briefed. He had flown the test runs during the day and had flown all of the tests the previous night. At the time of this experience he was flying from the first officer's seat.

1.16 Other Aspects

At the time of the last communication from EAL 663, 1825:36 there was apparently no distress in the cockpit. It is assumed that the flight crewmembers at this time were capable of performing their duties with respect to the flight. The PAA 212 crew indicated that, at the time of passing, the DC-7 was in a right bank of approximately 90 degrees at an altitude of approximately 2,600 feet. The calculated time of passage is 1826:26. The airplane lost 2,600 feet and recovered to an almost normal attitude in the next 14 seconds when it hit the water at 1826:40. The 14 seconds from passage to impact is compatible with the results of an IBM digital computer program provided by the Douglas Aircraft Company in those cases where impact or near impact resulted.

A number of cases were evaluated by the computer with the "hands off" condition during that portion of EAL 663 from passage to impact. The aircraft was held

ous bank angles to the 2,000-foot level and with "hands off" the possible recovery was determined. For angles up to and including 60 degrees the aircraft made a "zoom type" recovery. In the case of 70 degrees and 80 degrees bank angles the aircraft failed to recover, impacting at 26 degrees and 44 degrees nosedown attitude, respectively.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

Examination of the evidence indicates that structural components, controls, powerplants, and systems were capable of normal operation prior to initial impact of EAL 663; that weather was not a factor, that necessary and pertinent requirements for dispatching, crew qualifications, maintenance and operation have been complied with prior to the departure of EAL 663 from the JFK Airport. The captain was piloting the aircraft from the left seat and the first officer was handling the communications. It is indicated by the structural evidence that the airplane struck the water in a slightly nose up and slightly right wing down attitude.

2.2 Flightpaths

In order to develop a probable path of flight for EAL 663, data were established on the premise that the aircraft was flown according to operating procedures delineated in Eastern Air Lines DC-7B Airplane Flight Manual. Aircraft headings were considered to be precisely those specified by ATC in the several instructions and/or clearances. Winds aloft and temperatures were considered to be identical to the observations made at JFK. Aircraft performance was considered to be equal to performance data for a DC-7B at 104,000 pounds as provided by the Douglas Aircraft Company.

Application of these data to a pictorial display resulted in the EAL 663 flightpath shown in Attachment #3. The PAA 212 flightpath was developed from the flight recorder readout in Attachment #1 and the application of the aforementioned wind and temperature corrections. However, analysis of the EAL flightpath and its association with the impact site requires consideration of certain variables i.e., either the aircraft was not flown in accordance with the procedures in the Airplane Flight Manual, or the headings were not followed precisely, or the winds aloft were not as reported.

At 1825:31 EAL Flight 663 was instructed to turn to a heading of 170 degrees. On the basis of the computed flightpath, the aircraft would then have been two miles from the crash site if a uniformly curved flightpath were flown. If the turn had been delayed some 20 seconds and a nearly rectangular pattern flown, the aircraft would have been about 2-1/3 miles from the crash site. Since the time of impact has been determined to be 1826:40, the time from clearance to turn to the 170-degree heading until impact would be one minute and nine seconds. For a distance of two miles the average groundspeed would have to be approximately 104 knots, and for a distance of 2-1/3 miles it would have to be 120 knots. As this is slower than the DC-7B would fly under the circumstances involved it must be concluded that the data used are not entirely in consonance with the manner in which the aircraft was operated. Accordingly, the computed flightpath is not precisely representative of the flightpath actually flown.

Other reasoning which forces a conclusion that the computed flightpath is not entirely compatible with a probable flightpath is that the crew of EAL 663 acknowledged the turn instructions and "signed off" with the salutation "Good night" some 50 seconds prior to passing abeam PAA 212. Under normal circumstances the EAL DC-7 would have to be at least 3 to 3-1/2 miles from the point of passage at this time. Attachment #3, however, shows a distance of only 1-1/2 miles. Since the crew did not indicate any difficulties with the aircraft it can be presumed that the operation was normal or near normal at the time EAL 663 started the turn to the 170-degree heading. Also, passage would have occurred prior to the "Yeoh" transmission at 1826:19.

A number of calculated flightpaths of EAL 663 were developed by the Board staff taking into account the testimony of the AR-3, DR-1, and DRHO controllers concerning the relative position of the two airplanes at the time EAL was turned to the 170-degree heading, as well as its location at the time the AR-3 controller pointed out the target to the Approach Sequence Controller. The following factors were utilized for one projected flightpath:

(a) EAL 663 precisely at the handoff point described, i.e., three miles from the DPK 228-degree radial and at the time of the handoff (1824:20).

(b) EAL 663 was heading 150 degrees at handoff.

(c) EAL 663 turned to 090 degrees at 1824:30.

(d) EAL 663 turning immediately to 170 degrees upon receiving the turn instructions at 1825:21. (This is despite the fact that the DR-1 controller reported that 663 did not turn immediately. However, the immediate turn is used to keep the flightpath as short as possible.)

In order to arrive at the average position as reported by the aforementioned controllers it would be necessary for EAL 663 to have proceeded on a track of approximately 042 degrees instead of the 090 degree heading assigned. In 51 seconds it would have to travel approximately six miles or more at an average groundspeed of 423 knots. Thereafter, the aircraft would have to turn to a heading of approximately 236 degrees and travel the seven miles to the crash site at an average groundspeed of 365 knots. That an aircraft would proceed on a track 50 degrees displaced from the assigned heading without causing some concern and query on the part of the controller is difficult to accept.

Additionally, not only would such a flightpath be necessary, but in order to pass PAA 212 in close proximity in a 90-degree banked turn to the right, it would be necessary for EAL 663 to cross PAA 212's flightpath several times.

Since the above circumstances are completely beyond the capability of the aircraft it must be concluded that the JFK Tower controllers' statements concerning the location of EAL 663 at the time of the turn to 170 degrees and/or the location at the time of handoff are in error.

The locations of EAL 663 reported by the DR-1, DRHO, Approach Sequence and AR-3 controllers could be as much as a mile further west than they indicated. However, the DR-1 controller testified that EAL 663 had already crossed the projected flightpath of PAA 212 when he issued the turn instructions and that PAA 212

was on a northeast heading at the time. The reduction in distance would be insignificant and reduce the required speed to approximately 400 knots to reach the indicated positions at 1825:21.

Even if the handoff location is considered to be a mile east of the JFK 160-degree radial, and the EAL 663 position a mile west of the place stated by the controllers, which certainly is the most optimistic and favorable condition possib in light of their testimony, it still would be necessary for EAL 663 to cover the distance of four miles in 51 seconds, or in other words, to proceed from one point to the other at a groundspeed of 282 knots. This would be approximately 80 knots greater than the normal operating speed for the aircraft under the existing conditions.

One flightpath for EAL 663 has been projected on the basis of the testimony of the PAA 212 captain, first officer, and RR-7 (center) controller. This flightpath was plotted with that developed for PAA 212 and is pictorially displayed on Attachment #4. The following factors were used in the projection of the EAL 663 flightpath:

The captain of PAA 212 estimated that 40 to 45 seconds elapsed from the start of EAL 663's turn toward them until it passed them. He also estimated that had the traffic in sight for a minute and 15 to 20 seconds from the first observation to the time of passing. PAA 212 acknowledged the traffic call at 1825:00, 1:26 minutes prior to the passing.

The PAA first officer estimated the elapsed time from the start of EAL 663's turn toward them until it passed to be 40 to 50 seconds.

The RR-7 controller testified that the turn was accomplished in two to three sweeps of his radar, and the target proceeded on a southerly course for an additional two sweeps before the targets merged. The time interval between sweeps on the radar used by him is ten seconds. The time interval of target observation could be as little as 11 seconds and as much as 29 seconds for two sweeps, 21 to 39 seconds for three sweeps, and 31 to 49 seconds for four sweeps. The average of these three times resulting from the foregoing testimony and computations is 4 seconds from the start of the turn until the time EAL 663 passed abeam PAA 212.

The turn was described by the PAA 212 crew as faster than normal but not abrupt. Based on these observations and the testimony of RR-7 controller we calculated that the turn took 20 seconds, since on the next sweep the target was southbound, and was observed for two additional sweeps.

A four-degree per minute average rate of turn would be consistent with this testimony and result in the turn being accomplished in 20 seconds. Accordin the flightpath shown from point of passage was plotted on the basis that EAL 663 had completed the turn to the assigned heading of 170 degrees; that it was on thi heading for approximately 23 seconds prior to passing PAA 212 and that it was proceeding at a groundspeed of 206 knots. This groundspeed is based upon the normal performance characteristics of a DC-7B operated generally in consonance wi the instructions in EAL's DC-7B Airplane Flight Manual, and under the wind and temperature conditions shown in the data in Attachment #3.

The average rate of turn of four degrees per second requires an average 35-degree bank angle, which is within five degrees of the 30-degree bank angle

normally considered maximum for passenger confort in DC-7 aircraft. The radius of turn resulting from a four-degree rate of turn is approximately 4,100 feet. Using these data a flightpath was projected on a heading reciprocal to 170 degrees, beginning at the previously determined point of passage, for 23 seconds at a groundspeed of 206 knots. Application of wind drift then produced a track of 165 degrees. A turn of 4,100 feet radius was then plotted from the resulting track to the reciprocal of a 090-degree heading. The foregoing computations produce a turn to the 170-degree heading beginning at 1825:43. At this time, PAA 212 and EAL 663 were separated by four miles with PAA 212 at the 3 o'clock position of EAL 663. It should be noted that this distance is entirely compatible with the departure controller's testimony. It is also compatible with the captain's estimate of four to five miles separation when EAL 663 started the turn.

All distances and bearings shown on the computed flightpath on Attachment #4, relating to the various traffic advisories or traffic discussions, are well within reasonable tolerances for the range and distance estimates given by the controllers. These estimates were by four different persons and cover a period of time and place in the flightpaths, when the location of either aircraft is not in dispute by any of them, and for the most part, prior to any emergency. Accordingly, this is considered confirming information for the flightpath shown on Attachment #4.

A further confirming factor is the RR-7 controller's statement that after being advised of EAL 663 being turned to 090 degrees and observing this turn, the aircraft proceeded "approximately three miles or more, possibly five." The distance shown on the probable flightpath measures 3-1/2 miles from the start of the turn to 090 degrees to the beginning point of the turn to 170 degrees. If the turn to 170 degrees had not been delayed, this distance would have been less than three miles.

On the basis of the foregoing, it is believed that the flightpaths depicted in Attachment #4 for both EAL 663 and PAA 212 are representative of the probable flightpaths for the last three minutes of flight prior to the crash.

At the time of this accident the Air Traffic Control Standard Operating Procedures in use, together with the Letter of Agreement and its supplement, were designed to permit routine operations without prior coordination between the arrival and departure controllers. The testimony of the controllers in this instance, however, shows a deviation from standard procedures in that EAL 663 was vectored outside of the airspace normally allocated for departures. This deviation was based upon the DR-1 controller's determination that EAL 663 could not cross the 157° radial of the JFK VORTAC at 4,000 feet, as required by the Standard Operating Procedures. The deviation required initial coordination and subsequent frequent additional coordination between the DR-1 and the AR-3 controllers concerning the headings, and/or the altitudes of their respective aircraft in order that appropriate separation criteria (3 miles horizontally or 1,000 feet vertically) could be provided and maintained. The deviation would also require coordination between the DR-1 controller and the DRHO controller in order to effect an appropriate hand-off of EAL 663 to the New York Center controller. However, the Board finds no record of effective coordination between the controllers. In reaching this conclusion the Board considered the following circumstances:

Initial coordination, limited to the position of each aircraft was effected between the DR-1 controller and the AR-3 controller when the deviation

was initiated. However, the DRHO controller was not advised that EAL 663 would not be at 4,000 feet when it approached the hand-off area (in the vicinity of the JFK [illegible]VOR 160° radial and 3 miles north of the Deer Park VORTAC 228° radial). In the absence of this information the DRHO controller initiated the hand-off on the basis of his previous experience with aircraft being controlled in conformity with the Standard Operating Procedures rather than on the basis of specific knowledge of the respective altitudes of EAL 663 and PAA 212. As a result, in response to a query from the New York Center controller concerning a potential heading conflict between the two aircraft, the DRHO controller replied, "Yeah, we're (EAL 6[illegible] (PAA 212)" when in fact PAA 212 was the higher aircraft. The DRHO controller testified that immediately after giving this misinformation he overheard the [illegible] controller state "I am leaving three I am going eastbound" and the AR-3 [illegible] state "I am leaving 4500." Upon obtaining the correct information from the AR-3 controller the DRHO controller advised the New York Center that Kennedy Departure [illegible] was "going to hang onto Eastern 663 for awhile, we don't have quite a [illegible] feet there, we're turning him, then we will turn him back to you."

The conversation which the DRHO controller overheard was the only exchange of altitude information between the DR-1 and the AR-3 controllers with respect to EAL 663 and PAA 212, although the situation faced by the DR-1 controller, was one in which his aircraft was at a lower altitude than the arriving aircraft in whose direction the departure was heading and for effective coordination it was incumbent upon him to frequently ascertain the altitude of his aircraft as well as that of the arriving aircraft. As an alternative to vertical separation the DR-1 controller could afford the aircraft horizontal separation, provided he was kept aware of headings assigned to the arriving aircraft by the AR-3 controller. In this regard, the DR-1 controller testified that he did not recall an awareness of the heading of 360° subsequently given to PAA 212, which placed the two aircraft on nearly head-on courses. Earlier at the time of initial coordination, the departure controller had alternative courses of action which would assure that adequate separation would continue to exist. He could have requested EAL 663 to expedite its climb to achieve the desired 4,000-foot altitude or he could have instructed EAL 663 to make a climbing 360° turn which would have given the flight more time to reach 4,000 feet.

When the departure controller was advised that inbound traffic was not a factor to EAL 663's departure, he proceeded to vector the flight on an approximate direct heading to Dutch Intersection. Within a minute thereafter he identified PAA 212 and observed the progressive closure of the two targets. Again, the departure controller was faced with alternative courses of action. One was to turn EAL 663 to a southerly heading and have him pass west of PAA 212. Another, which he chose, was to turn EAL 663 to an easterly heading and have the flight continue to climb until 1,000 feet or more altitude separation was achieved.

Notwithstanding the testimony of the DR-1 controller that he was utilizing solely horizontal separation, the Board believes that he was aiming for vertical separation and that horizontal separation was being used only until vertical separation between the two aircraft had been achieved. This is substantiated by the previously quoted communication from the DRHO controller in regard to the transfer of control of EAL 663 to the New York Center. It is further supported by his testimony, in which he stated that in his opinion vertical separation was being applied and that transfer of control would take place when "Eastern was a

thousand feet on top of Pan American", and by the fact that he was never advised to the contrary by the DR-1 controller. That vertical separation was being aimed for is also implied in the DR-1 controller's testimony in explanation of the basis on which he issued EAL 663 the turn to 090°. He stated the turn was "to maintain at all times more than three miles horizontal separation from the Pan American Clipper. I believe that is why I gave him a heading of 090° at the same time to give the aircraft a chance to continue his climb."

The Board believes that as the situation developed, vertical separation in the order of 1,000 feet did in fact exist between the aircraft when they were about 3 miles apart, but this was unknown to the controllers. This is because in order for the DR-1 controller to provide this separation it was necessary for him to receive reports originating from the aircraft which would assure him that they were, and would continue to be, separated vertically by at least 1,000 feet and this information was never received. For the same reason the Board is unable to reconcile the statement of the DR-1 controller, in his call of traffic for EAL 663 "below you", as being more than an assumption since the last information received by him relative to PAA 212 was that it was leaving 4,500 feet.

Below is a tabulation showing in chronological order the transmissions to and from each of the aircraft regarding altitude, together with corresponding altitude values derived from the PAA flight data recorder and the reported or computed altitudes of EAL 663.

	ATC TRANSMISSIONS		ALTITUDES	
TIME	EAL 663	PAA 212	EAL 663 (Reported or Computed)	PAA (Flight Recorder)
1822:52	"Out of 2500'"		2500'	5500'
1823:41	"Out of 3000'"		3000'	4950'
1824:24		"Out of 4500'"		4325'
1824:28	"Out of 3500'"		3500'	4300'
1824:50		"Traffic 11 o'clock 5 miles SE bound climbing out of 3000'"		4050'
1824:56		"Leaving 4000"		4000'
1825:03	"Out of 3700'"		3700'	3925'
1825:21	"Turn right heading 170° traffic 2 o'clock 5 miles ... below you"		3850'	3600'
1825:37		"Out of 3500'"	3990'	3400'

As the tabulation shows, at the moment of the traffic call to EAL 663, PAA 212 was approximately 250 feet below EAL 663's altitude. This vertical distance, however, would be considerably less than the 1,000 feet or more that a pilot would normally expect in consequence of a call of known traffic as "below you."

The Sperry Gyroscope Company Study previously discussed noted that in test runs in which a vertical miss vector of 250 feet was present at an initial range

of 5 miles the pilots being tested decided that a collision course existed in 16 percent of the cases. In these instances a horizon line was available which would assist the pilot in determining the relative altitude of the intruder aircraft. In those instances where a horizontal miss vector of 250 feet existed at five miles initial range and a reference line was not available, a decision was made that a collision course existed in 52 percent of the cases. It is not unlikely, therefore, that when PAA 212 was observed through the first officer's side window, against a featureless background at a five-mile range, the PAA aircraft could well appear to be at the same altitude as EAL 663 and thus present a collision threat.

The remaining questions concern the delay in the execution of the turn to 170 degrees, which instruction was initiated at 1825:21, received by the crew at 1825:26 and acknowledged at 1825:31, and the reason for a faster than normal turn.

On the basis of the data used in developing the probable flightpath on Attachment #4 the turn would have been established at 1825:43 or about 17 seconds after the receipt of the turn instruction by the crew. Approximately five seconds of this would be pilot/aircraft response time. It is our belief that in the remaining 12 seconds the crew of EAL 663 was attempting to locate their traffic and assess the collision potential. Since this traffic was at their 3 o'clock position, instead of 2 o'clock, it probably would not be seen by the captain, but could have been and likely was seen by the first officer. A continued preoccupation with potentially conflicting traffic, both prior to initiating the turn and afterwards, is implied in EAL 663's failure to contact either the company or the New York Center after concluding communications with the Kennedy Departure Controller at 1825:36, some 50 seconds before the aircraft passed each other. The 12 seconds delay is reasonable and consistent with the DR-1 controller's testimony on this subject.

EAL 663 commenced the turn from 090 degrees to 170 degrees at approximately 1825:43. With the EAL's aircraft in a 35-degree banked nearly level turn and with PAA 212 approximately 700 feet lower and four miles away at 3 o'clock instead of 2 o'clock, PAA 212 would not be visible to the captain of EAL 663 until he was nearly around the turn and on the rollout. Since PAA 212 would not be visible to the captain throughout his turn, it would then be necessary for him to locate this traffic upon completion of the turn. At this time EAL 663 would be on a nearly head-on, converging course with PAA 212. Separation would be on the order of 2-1/2 miles. The time of completion of the turn would be about 1826:03. PAA 212 would be at approximately 3,050 feet altitude, according to the flight recorder data. On the basis of the times ascribed to the events shown on the PAA 212 flight recorder readout, PAA 212 started a left turn to the assigned heading of 360 degrees at 1826:00. The results of this turn would be to produce even more of an apparent collision track than before. After the turn to 170 degrees the captain of EAL 663 would have had a total of 23 seconds available to him in which to (1) locate the other aircraft, (2) assess the degree of threat, (3) initiate an avoidance maneuver, and (4) complete the avoidance maneuver. During this time little or no attention could be given to the instruments because of the necessity to keep the other aircraft under continuous observation.

In view of the close proximity of PAA 212 and the decision times shown in the Sperry Gyroscope Company experiments it is apparent that the captain's decision would have to be made almost simultaneously with his observation of the traffic.

Since EAL 663 was turning away from the background lights of the Long Island shore into a black area, there was no horizon available to assist in the determination of the relative altitude of the target airplane. The single light source represented by PAA 212 provided an insufficient stimulus for the determination of depth and distance perception so that an intelligent decision as to vertical separation could not be made. Under these circumstances, it is likely that a descent was started, initially as a precautionary measure, which would give him a longer time to observe the other aircraft, and provide him with a measure of vertical separation. In this regard, it is noted that other pilots have testified that if they believed a collision course existed they would initiate a descent. The reasons given were that in climb the aircraft is limited in its maneuverability, and that the descent configuration would help keep the opposing traffic in sight.

If a pilot does undertake an avoidance maneuver with inadequate information, he cannot tell what effect it will have on the probability of collision. Once he has begun the maneuver, he no longer has the fixity criterion, nor can he know when to end the maneuver.

This was the situation confronting the EAL pilot which would remain until approximately ten seconds prior to passage. It is likely that initially the descent would appear to have EAL 663 proceed underneath PAA 212 and that there may have been a sight-line rate which would indicate that EAL 663 would pass to the east of PAA 212. However, at about ten seconds prior to passage, or some ten seconds after EAL 663 had started its descent, PAA 212 rolled rapidly to the right and also initiated a descent. That this maneuver might appear to the EAL pilot to again create an immediate collision hazard is evident in that it also appeared to do just that to the first officer of PAA 212. When this action took place and as it continued, the EAL captain, was left with no course of action other than a maximum effort right turn of his own, and possibly a pullup since the continued straight descent, or a left turn would further degrade the collision avoidance possibility. It is believed that this is the reason for the vertical right bank observed by the PAA 212 crew as EAL 663 passed. During the extreme right turn, the EAL captain would have no manner of knowing the actual attitude of his aircraft, or the degree of bank involved, since there were no visual clues available to him outside the cockpit. In order to achieve spatial orientation after the two aircraft had passed, it would be necessary for him to again refer to his instruments, determine his attitude by reference to them, and apply the necessary recovery control pressures. However, he would be operating in an unusual environment since 60 degrees is the maximum bank practiced in the DC-7 by EAL pilots in the course of their training.

The maximum roll rate of the DC-7 is 26 degrees per second. At 2,600 feet in a vertical bank immediate and appropriate corrective action would be necessary in order to effect recovery. However, this action would have to wait upon the EAL captain's evaluation if his instruments in order for him to apply control pressures of the proper magnitude and in the proper direction. In this context, an Air Force Study14/ using highly qualified instrument pilots, disclosed that as much as 36 seconds were required for a pilot to establish full control by instrumer

14/ Kraus, Ralph N., Disorientation and Evaluation of the Etiologic Factors, Report 59-90, Air University School of Aviation Medicine, USAF, Brooks Air Force Base, Texas, May 1959.

reference if orientation is lost. Thus it is likely that some seconds elapsed from the time EAL 663 and PAA 212 passed each other before the EAL captain would become spatially oriented. Consequently, the delay in control pressure application, or application of a great enough magnitude, resulted in the aircraft striking the water before recovery was completed.

2.2 Conclusions

(a) Findings:

1. There is no evidence of any malfunction of the aircraft, its engines, or components.

2. The aircraft was within weight and balance limits.

3. Dispatching was in accordance with company and Federal Aviation Agency regulations.

4. Weather was not a factor in the accident.

5. The crew was properly qualified and they were not incapacitated prior to the crash.

6. The captain was handling the controls of the aircraft.

7. The captain was unable to see PAA 212 during the turn from 090 degrees to 170 degrees.

8. The turn to 170 degrees was toward an area where spatial orientation could be accomplished only by reference to the aircraft instruments.

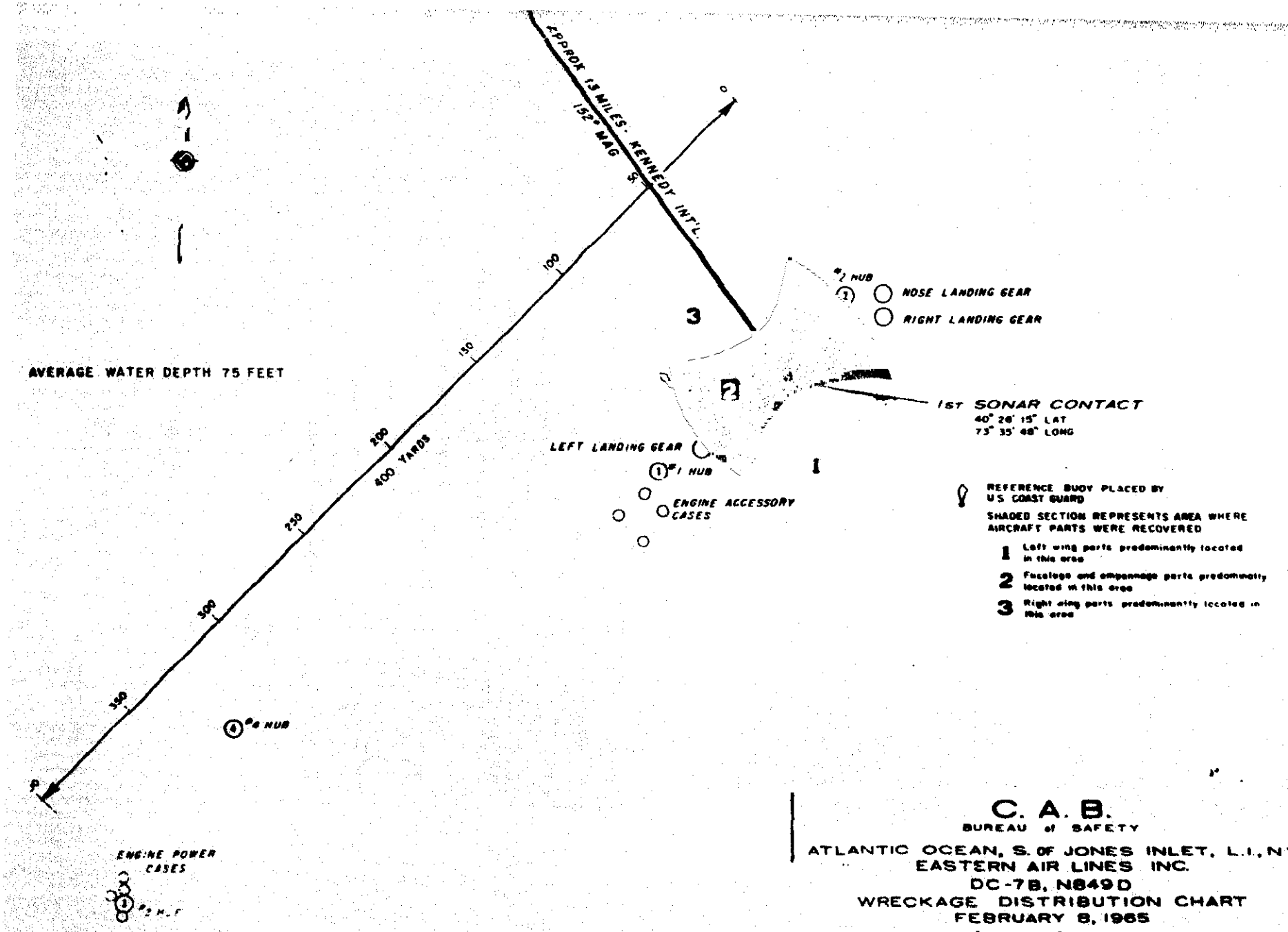
9. Required radar separation between EAL 663 and PAA 212 existed until the turn to 170 degrees. Upon completion of this turn radar separation ceased to exist. However, at this time the aircraft were separated vertically by approximately 1,000 feet although this was not known by the controllers involved.

10. Subsequent to the rollout on the 170-degree heading there was a rapid decrease in range between the two aircraft.

11. Neither sufficient time nor adequate information was available to the EAL captain in order for him to assess properly the relative altitudes of the two aircraft.

12. The EAL captain had the illusion that a potential collision course existed. As a result of this illusion a descent was initiated.

13. During this descent, PAA 212 executed an evasive maneuver that would appear to negate the action taken by the EAL captain. The only course of action available to EAL 663 at this time was a rapid roll to the right, and/or a pullup. In this circumstance the DC-7 was placed in an unusual attitude, resulting in spatial disorientation of the crew.

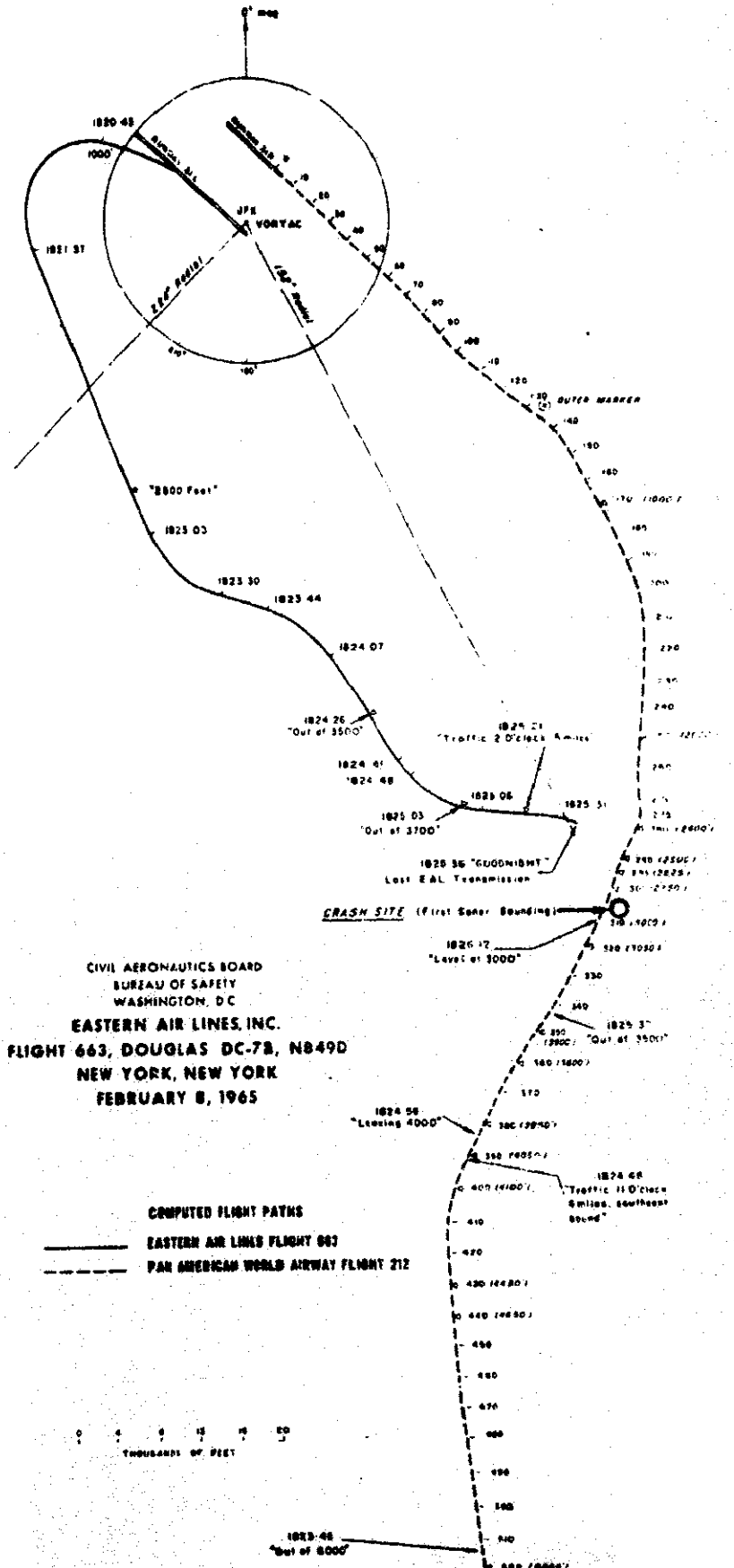


C. A. B.

BUREAU of SAFETY

ATLANTIC OCEAN, S. OF JONES INLET, L.I., N.Y.
EASTERN AIR LINES INC.
DC-7B, N849D
WRECKAGE DISTRIBUTION CHART
FEBRUARY 8, 1965

DRAWN BY WILLIAM LEWIS 4/2/65 | SCALE 1 inch = 20 Yards | STRUCTURES GROUP J. T. CHILDS, BO Chairman, B 96


1820 48
1000'
JFK VORTAC
1821 57
ZBF Radial
160° Radial
"8800 Feet"
1823 03
1823 30
1823 44
1824 07
1824 26
"Out of 3500"
1824 41
"1824 48
1825 03
"Out of 3700"
1825 05
1825 51
1825 21
"Traffic 2 O'clock 5 miles
1826 36 "GUDNIGHT"
Lost E.A.L. Transmission
CRASH SITE (First Sonar Sounding)
1826 12
"Level at 3000"
OUTER MARKER
1825 37
"Out of 3500"
1824 58
"Leaving 4000"
1824 48
"Traffic 11 O'clock
6 miles, southeast
bound"
1823 48
"Out of 6000"
CIVIL AERONAUTICS BOARD
BUREAU OF SAFETY
WASHINGTON, D.C.
EASTERN AIR LINES, INC.
FLIGHT 663, DOUGLAS DC-7B, N849D
NEW YORK, NEW YORK
FEBRUARY 8, 1965
COMPUTED FLIGHT PATHS
EASTERN AIR LINES FLIGHT 663
PAN AMERICAN WORLD AIRWAY FLIGHT 212
THOUSANDS OF FEET

ATTACHMENT #4

FLIGHT PATHS OF EAL [illegible] AND PAA 212
BASED UPON TESTIMO[illegible] OF THE RR-7 CONTROLLER,
THE CAPTAIN AND FIR[illegible] OF PAA 212